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Mustard Productivity Depends on Varietal Characteristics and Elements of Cultivation Technology

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Abstract

An important reserve for increasing the productivity of crops, in particular mustard, is the widespread introduction of new varieties for various uses, as well as the potential for grain yield and quality. Therefore, the study aimed to identify the patterns of formation of yield and quality of mustard seeds depending on varietal characteristics and elements of technology. The research results showed that the yield of mustard seeds depended on the varietal characteristics and the timing of their harvesting. The use of phosphorus-potassium fertilizers and one-time foliar fertilization on the seedlings and twice on the seedlings and in the rosette-stem phase provided a significant increase in the yield of mustard seeds at all harvesting dates compared to the control. The increase in seed yield was statistically significant and depended on the timing of harvesting. The highest yields were recorded when harvesting 40 days after flowering, both in the control group and when applying the main fertilizer and foliar fertilization against the background of the main fertilizer. In addition to seed harvesting timing and the impact of mineral fertilizers, varietal characteristics played a significant role in determining seed yield. Higher seed yields were observed for white mustard varieties Pidpecheretska and Oslava at all harvesting dates, providing 1.25 t/ha and 2.03 t/ha, respectively, regardless of fertilizer use or in the control group without fertilizers. At the same time, the weight of 1000 seeds naturally and significantly increased depending on the timing of seed harvesting, both in the control and in the case of mineral fertilizers.

Keywords

Variety; Yield; Fertilizers; Harvesting;, Germination energy; Weight of 1000 seeds; Soil and climatic conditions

Introduction

Oilseeds play an important role in the agricultural economy in many regions of the world. Mustard is a small-seeded oilseed from the cruciferous family, the range of use of which in the national economy is very wide. Ukraine is among the world's top ten producers of the crop in terms of acreage, and in terms of production, mustard ranks fourth among oilseeds, behind only rapeseed, soybean, and sunflower. High prices for mustard seeds in foreign markets and the ease of cultivation make it one of the most economically profitable crops, and its phytosanitary and agro-reclamation properties contribute to the more active inclusion of mustard in crop rotations (Havryliuk *et al.*, 2008). Rapid climate change toward warming contributes to the expansion of its cultivation areas, which significantly changes traditional ideas about the biological composition and technological capabilities of known crops (Jia *et al.*, 2021; Zhuykov, 2014). The introduction of modern high-yielding varieties is of practical importance for the maximum realization of the genetic and biological potential of the crop (Zhuykov and Zhuykov, 2013), so the improvement of technology elements to increase the yield of mustard seeds is relevant.

Important elements of mustard cultivation technology that determine the level of productivity are the use of mineral fertilizers and the timing of seed harvesting. Harvesting seeds in early or late terms leads to significant losses, which can vary in a large range, depending on the condition of the seed (browning of fruits or panicles, level of seed yield, degree of lodging, weediness of the field, etc.); proper adjustment of the mechanisms of harvesting machines (reaper, combine, picker) and design flaws of the machines (Mykolayko, 2025). Different criteria for assessing seed maturity are used to determine the harvesting time: morphological characteristics (indicators of browning of fruits or panicles), in days from the beginning of flowering of the seed pods, chlorophyll content in the seed coat, the sum of active temperatures during the harvesting period, with a higher sum of temperatures, the yield and germination of seeds will be higher (Palamarchuk *et al.*, 2022). According to Zhuikov (2006), the optimal time for harvesting mustard seeds is the yellow-green pod phase, and the seeds in the lower pods of the central stem acquire the color characteristic of this variety and have a moisture content of 30–33 %. Mustard seeds are harvested from weed-free crops at a moisture content of 12–15% during full seed ripeness. Harvesting is done directly within a short time frame of 3–4 days, preferably in the morning or evening (Kiforuk *et al.*, 2011; Shevchenko *et al*., 2019).

An effective element of the technology that ensures a significant increase in the yield of mustard is the use of mineral fertilizers, which respond well to their application, and especially nitrogen fertilizers, which can increase the yield by up to 30% (Oksymets and Larina, 2003). Voloshchuk (2024) found that in the Western Forest-Steppe of Ukraine, with the main application of mineral fertilizers at the rate of $N_{30}P_{30}K_{35}$ and additional fertilization with ammonium nitrate at the rate of N_{30} in the phase of BBCH 14–16, the yield of mustard seeds, depending on varietal characteristics, increased to 3.48–3.74 t/ha, which provided an increase of 1.73–1.79 t/ha over the control.

Studies on the effectiveness of the use of mineral fertilizers for growing mustard seeds, conducted in different soil and climatic zones of Ukraine, proved their high efficiency at

different doses (Gubenko and Lyubchych, 2020; Kirilyuk, Tymoshchuk, and Kalchuk, 2019; Vyshnivsky *et al.*, 2010). All studies that involved the use of mineral fertilizers were conducted without considering the varietal characteristics and their impact on seed maturation. Therefore, the objective of our experiments was to determine the patterns of yield formation and seed quality based on the application of mineral fertilizers, as well as the timing of their harvesting.

Methodology

Study Area

As part of the program, a study was conducted on the effectiveness of mineral fertilizers and the timing of mustard seed harvesting, taking into account varietal characteristics. The research was conducted at the experimental field of Pavlo Tychyna Uman State Pedagogical University of the Ministry of Education and Science of Ukraine in the period from 2020 to 2023. This field is located in the unstable moisture zone of the Right-Bank Forest-Steppe of Ukraine. The study examined the influence of technology elements on the yield and seed quality of four varieties of white mustard (*Sinapis alba*) – Etalon, Pidpecherytska, Ariadna, and Oslava, and one variety of black mustard (*Brassica nigra*), Tsarivna Pivnochi.

Research Scheme

The research scheme included the use of the main mineral fertilizer at a dose of $P_{45}K_{45}$ and one and two foliar fertilizations by seedlings and in the rosette-stemming phase with nitrogen fertilizers at a dose of N_{30}. Seeds were harvested in three periods: 30, 35, and 40 days after flowering.

Research Methods

Sowing was carried out by the usual row method with a seeding rate of 2 million seeds per hectare. Seed yield was determined by weighing the plots from each replication. Average seed samples were collected and their quality – germination energy, germination rate, and weight of 1000 seeds – was determined according to DSTU (National Standard of Ukraine, 2002).

Soil and Weather Conditions

The weather conditions during the years of research were close to the average long-term temperature regime and differed in terms of moisture supply. The growing seasons of 2020, 2022, and 2023 were characterized by moisture deficits, with precipitation deficits of 36.2, 114.2, and 50.3 mm, respectively, and only in 2021 was there a slight waterlogging, with precipitation 50.3 mm above the long-term average. The soil at the experimental site is a podzolized heavy loamy chernozem characterized by a lumpy-dusty structure with a low humus content of 3.31 %. The reaction of the soil solution is neutral - pH 6.5-6.7. The content of mobile phosphorus, according to the Chirikov

method (DSTU 4115-2002, 2002)[1] and potassium is 80-130 mg/kg, which is an average availability.

Statistical Analysis

The reliability of the experimental data was assessed by the calculation-comparative method using the analysis of variance according to Fisher's method (Fisher, 2006) and guidelines (Ehrmantraut, Prysiazhniuk, and Shevchenko, 2007).

Results

It was determined that the yield of mustard seeds depended on the varietal characteristics and the timing of their harvesting. On average, over the years of research, the highest yield of all varieties was obtained when harvested forty days after the end of flowering, which, depending on the use of mineral fertilizers, was 1.18-1.92 t/ha (Table 1).

Table 1: Seed yield (t/ha) depending on fertilizer application and harvesting time (average for 2020–2023)

Variant – application of fertilizers	*Harvesting period, in days, after flowering*		
	30	*35*	*40*
No fertilizer – control	1.00	1.08	1.18
$P_{45}K_{45}$ in the main application without fertilizing	1.34	1.42	1.49
$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.67	1.64	1.77
$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.79	1.86	1.92
$LSD_{05\ general}$	0.05		
$LSD_{05\ fertilizer}$	0.03		
$LSD_{0.05\ harvesting\ time}$	0.03		

The use of phosphorus-potassium fertilizers and one-time foliar fertilization on the seedlings and twice on the seedlings and in the rosette-stem phase provided a significant increase in the yield of mustard seeds at all harvesting dates compared to the control. A significant increase in seed yield was obtained depending on the time of harvesting. If in the control – without fertilizers for harvesting seeds 30 days after flowering, the yield was 1.0 t/ha, then after 35 days it increased by 0.08 t/ha, and after 40 days by 0.18 t/ha. A similar increase in seed yield was obtained by using fertilizer.

The highest seed yield was obtained when harvested 40 days after flowering, both in the control and when applying the main fertilizer and foliar fertilization against the background of the main fertilizer. With phosphorus-potassium fertilizer without fertilization, the yield increased by 0.31 t/ha, with a single foliar feeding on the seedlings on the background of the main fertilizer, by 0.59 t/ha, and with two foliar feedings on the

[1] DSTU 4115-2002 Soils. Determination of mobile compounds of phosphorus and potassium according to the modified Chirikov method [in Ukrainian].

seedlings and in the rosette-stem phase, by 0.74 t/ha compared to the control. Foliar fertilization against the background of the main phosphorus-potassium fertilizer provided a significant increase in seed yields, both compared to the control and only with the application of the main fertilizer, without fertilization. When seeds were harvested 40 days after flowering, the seed yield was significantly higher compared to the control and earlier harvesting dates. Along with the timing of seed harvesting and the effect of mineral fertilizers, varietal characteristics significantly influenced the seed yield (Table 2).

Table 2: Seed yields (t/ha) depending on varietal characteristics, fertilizers, and harvesting time (average for 2020–2023)

Variant		*Harvesting period, in days, after flowering*		
variety	*fertilizers*	*30*	*35*	*40*
Tsarivna Pivnochi	No fertilizer – control	0.95	0.99	1.11
	$P_{45}K_{45}$ in the main application without fertilizing	1.11	1.14	1.30
	$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.49	1.54	1.68
	$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.55	1.66	1.76
Etalon	No fertilizer – control	0.93	1.03	1.12
	$P_{45}K_{45}$ in the main application without fertilizing	1.37	1.43	1.48
	$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.60	1.65	1.69
	$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.76	1.82	1.88
Pidpecheretska	No fertilizer – control	1.05	1.17	1.25
	$P_{45}K_{45}$ in the main application without fertilizing	1.43	1.50	1.54
	$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.70	1.77	1.84
	$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.88	1.93	1.98
Ariadna	No fertilizer – control	1.00	1.08	1.17
	$P_{45}K_{45}$ in the main application without fertilizing	1.40	1.45	1.52
	$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.65	1.70	1.75
	$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.85	1.91	1.98
Oslava	No fertilizer – control	1.07	1.16	1.25

Variant		*Harvesting period, in days, after flowering*		
variety	*fertilizers*	*30*	*35*	*40*
	$P_{45}K_{45}$ in the main application without fertilizing	1.38	1.55	1.62
	$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	1.73	1.82	1.88
	$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	1.91	1.98	2.03
$LSD_{05\ general}$		0.05		
$LSD_{05\ variety}$		0.03		
$LSD_{05\ fertilizer}$		0.03		
$LSD_{05\ harvesting\ time}$		0.04		

Significantly higher seed yields at all harvesting dates, regardless of the use of fertilizers or in the control, without fertilizers, were provided by the white mustard varieties Pidpecheretska and Oslava. Thus, 40 days after flowering, the yield of the Pidpecheretska variety was 1.25 t/ha in the control and 1.98 t/ha with two fertilizing treatments against the background of the main fertilizer and Oslava, respectively, 1.25 t/ha and 2.03 t/ha. The lowest seed yield was obtained in the black mustard variety Tsarivna Pivnochi, which, 40 days after flowering, was 1.11 t/ha in the control and 1.76 t/ha with two fertilizations. The yields of white mustard varieties Etalon and Ariadne were significantly lower than those of varieties Pidpecherecka and Oslava, and significantly higher than those of the black mustard variety Tsarivna Pivnochi. A similar dependence was observed when seeds were harvested 30 and 35 days after flowering.

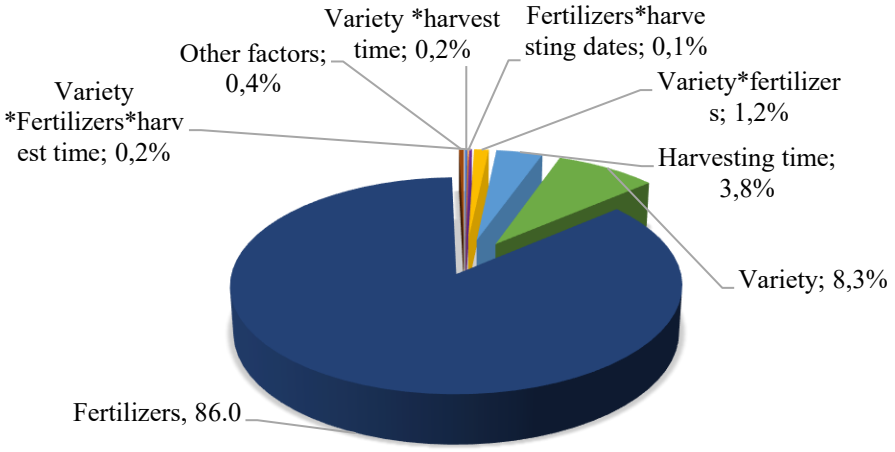

Figure 1: Influence of factors on seed yield depending on varietal characteristics, fertilization, and harvesting time (average for 2020–2023)

The analysis of variance revealed that the greatest influence on the formation of seed yield depending on varietal characteristics, harvesting time and fertilizer application was the factor «fertilizer», which amounted to 86.0 %, the influence of the factor «variety» was much smaller and amounted to 8.3 %, and the influence of other factors and their interaction was insignificant (Figure 1).

Without high-quality seeds, it is impossible to obtain high yields of crops, including mustard. The literature on the study of the impact of mineral fertilizers on the cultivation of mustard seeds focuses mainly on their impact on seed yield and oil content, and almost no results of the impact of fertilizers on seed quality indicators – germination energy and germination. However, for all crops, seed germination is regulated by standards. For mustard, it should be at least 85 %. It is worth noting that, on average, over the years of research, seed quality – germination energy and germination rate in all variants were high, more than 90 %, and there was no significant difference depending on the timing of harvesting and application of mineral fertilizers (Table 3).

Table 2: Seed quality (%) depending on the use of fertilizers and harvesting time (average for 2020–2023)

Variant – application of fertilizers	*Harvesting period, in days, after flowering.*					
	30		*35*		*40*	
	germination energy	*similarity*	*germination energy*	*similarity*	*germination energy*	*similarity*
No fertilizer – control	94	94	95	95	96	96
$P_{45}K_{45}$ in the main application without fertilizing	97	97	96	97	95	96
$P_{45}K_{45}$ in the main application + fertilizer N_{15} in the seedlings	94	95	96	96	96	97
$P_{45}K_{45}$ in the main application + two fertilizing N_{15} in the seedlings + N_{30} in the rosette-stemming phase	94	95	95	96	95	95
$LSD_{05\ general}$	2.1	2.0	2.1	2.0	2.1	2.0
$LSD_{05\ harvesting\ time}$	1.6	1.5	1.6	1.5	1.6	1.5
$LSD_{05\ fertilizer}$	1.7	1.6	1.7	1.6	1.7	1.6

The use of mineral fertilizers did not provide a significant increase in germination energy and seed germination compared to the control, depending on the time of harvesting. If the main application of phosphorus-potassium fertilizers is at an early harvesting date, 30 days after the end of flowering, the germination energy and seed germination rate were 97%, then when harvested 35 days after flowering, these indicators were 96% and 97%, respectively. Similar results were obtained when foliar fertilization was carried out against the background of the main fertilizer and in the control, without fertilizers.

The analysis of variance found that the influence of the studied factors on the formation of germination energy and seed germination depending on the timing of harvesting and fertilizer application was almost the same, namely: «fertilizers», respectively – 38.4% and 39.2%, the influence of the factor «harvesting time» – 30.0% and 28.1% and their interaction, respectively – 24.6% and 26.4% (Figure 2).

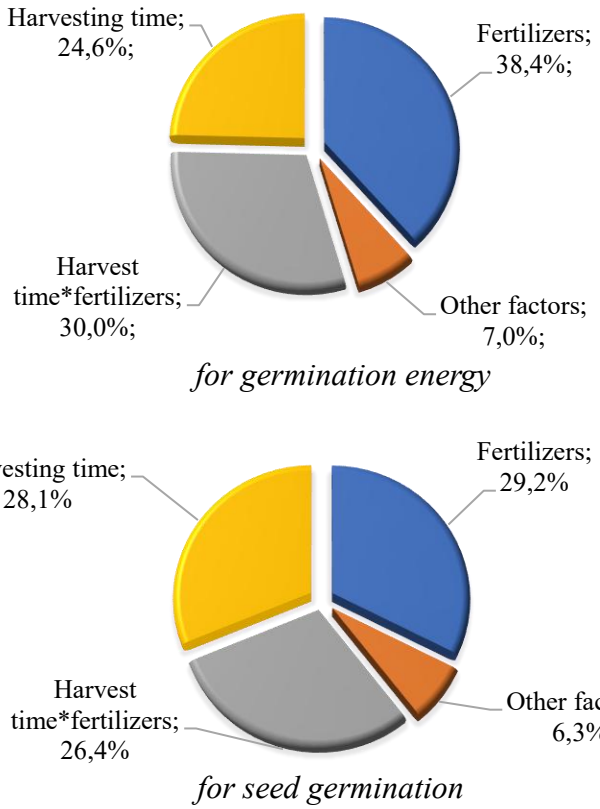

Figure 2: Influence of factors on seed quality depending on the timing of harvesting and fertilization (average for 2020–2023)

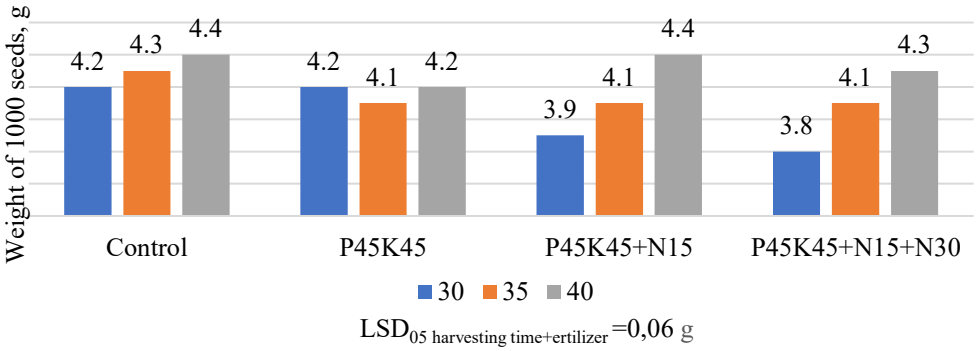

Figure 3: Weight of 1000 seeds depending on the timing of seed harvesting and fertilization (average for 2020–2023)

In contrast to the formation of germination energy and seed germination, the weight of 1000 seeds naturally and significantly increased depending on the timing of seed harvesting, both in the control and when mineral fertilizers were applied (Figure 3).

Thus, if in the control for harvesting seeds 30 days after flowering, the weight of 1000 seeds was 4.2 g, then after 35 days it was 4.3 g, and after 40 days, 4.4 g (LSD $_{05}$ = 0.06 g). A similar increase in the weight of 1000 seeds was obtained with the main fertilization with phosphorus-potassium fertilizers and foliar fertilization with nitrogen fertilizers. The analysis of variance revealed that the formation of the mass of 1000 seeds, depending on the timing of harvesting and fertilizer application, was most influenced by the factor «harvesting time» – 43.0%, the influence of the factor «fertilizer» was less and amounted to 32.0%, and the interaction of these factors and other factors was much smaller (Figure 4).

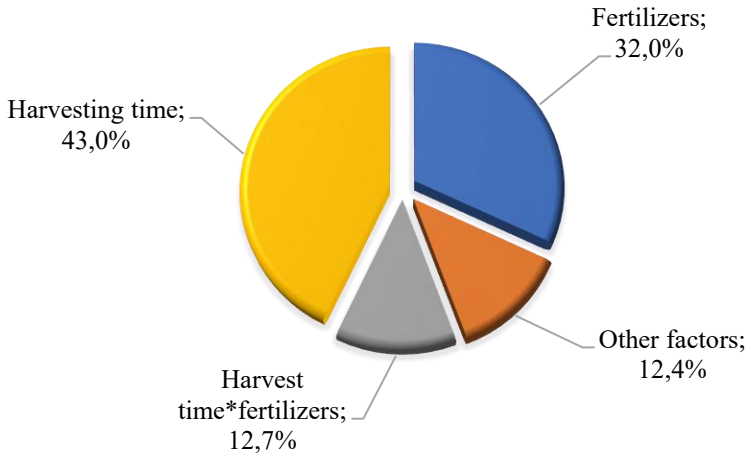

Figure 4: The share of influence of factors on the formation of 1000 seeds depending on the timing of harvesting and fertilization (average for 2020–2023)

Depending on the varietal characteristics of white mustard and the time of harvesting seeds, no significant difference was found in their quality, germination energy, and germination rate, except for the quality of black mustard seeds. The germination energy and germination rate of the seeds of black mustard, Tsarivna Pivnochi, were significantly lower than those of all white mustard varieties, both at earlier and later harvesting dates.

Discussion

The rapid growth of the world's population, climate change, and food shortages are becoming major problems of our time (Konovalov *et al.*, 2024). It is well known that the growth and development of crops are influenced by genotype, soil type, water, and climate. Climate change is one of the most unpredictable areas of environmental change, which determines the need to search for more environmentally adapted crops (Das, 2009; Ivanyshyn and Kasiyanchuk, 2024; Pham *et al.*, 2024). Demand for mustard has been growing recently due to its ability to grow in a variety of agro-ecological conditions, including relatively low temperatures and disturbed soils, making it well-suited for home cultivation and industrial use (Angelova and Ivanova, 2009). Mustard production is also expected to grow significantly due to the growing use of its seeds in the food,

pharmaceutical, and cosmetic industries (Kakabouki *et al.,* 2020; Rahman *et al.*, 2018). Given the steady growth in demand for mustard, finding ways to increase its yield is essential (Sharma *et al.*, 2025).

It was found that different levels of nitrogen application affect the grain yield of mustard. The maximum grain yield, which was 1.53 t ha^{-1}, was observed when nitrogen was applied at a rate of 190 kg ha^{-1}. With a decrease in the rate of nitrogen application to 90 kg/ha^{-1}, the yield decreased to 1.10 t ha^{-1}. The weight of 1000 seeds, respectively, varied from 3.57 g at 190 kg ha-1 to 2.20 g at 90 kg ha^{-1} (Hashan *et al.*, 2023). Khamzina *et al.* (2023) found that the seed yield of mountain mustard variety Rushen (*Brassica juncea* (L.) Czern.) and common mustard variety Profi (*Sinapis alba* L.) increased in response to ammophos application compared to the control, with the maximum yield (2.07-2.22 t/ha^{-1}) achieved with ammonium phosphate fertiliser at T5 and T6 ammophos rates in both variants on both varieties. Studies by Jankowski, Zaluskib, and Sokolskia (2020) found that nitrogen had an impact on the formation of the yield of mustard varieties Radena and Warta up to a rate of 120 kg ha^{-1}. Nitrogen fertilisation had the most favourable effect on the weight of 1000 seeds in particular.

According to our previous studies (Mykolaiko *et al.*, 2024), the introduction of $P_{45}K_{45}$ with two fertilisers N_{15} and N_{30} in the rosette-stem phase increased the yield by a maximum of 0.26 t/ha, while with similar fertilisation, taking into account the harvesting time factor, it increased by 0.43 t/ha, which is significant and indicates the expediency of shifting the harvesting time.

Melnychuk's research (Melnychuk *et al*., 2024) has determined that the optimal time for sowing white mustard in the conditions of the Precarpathian region is when the soil reaches physical ripeness at a temperature of 5-10 °C, which ensures the highest yields, which exceed the following terms by 10-25%. Under the conditions of unstable moisture in the central Forest-Steppe zone of Ukraine, the maximum seed yield (1.81 t/ha), oil yield per hectare (0.560 t/ha) and individual productivity were ensured by the first (early) sowing of white mustard with the application of a fertiliser dose of $N_{45}P_{45}K_{45}$ (Blashchuk and Tereshchenko, 2014). The results of our previous studies also confirm that the optimal time for sowing mustard is early, when the soil temperature at a depth of 10 cm is 6-7 0C. Approximately, this period falls on the first and second quarters of April (Mykolaiko *et al.*, 2025).

Studies on the influence of sowing dates on mustard yield have been conducted in sufficient numbers and under different growing conditions, while there is little data on the influence of harvesting dates on the corresponding indicator. Kandel (2022) notes that mustard should be harvested when the seeds are fully ripe, i.e., 85-90 days after sowing yellow mustard and 90-95 days for brown and oriental mustard. However, the author does not indicate the impact of these terms on the quantitative indicators of yield and seed quality. As a result of our research, it was determined that the maximum yield of mustard was obtained by harvesting seeds 40 days after flowering with the introduction of $P_{45}K_{45}$ in the main feeding and N_{15} on the seedlings, which indicates the need for further research in different growing conditions.

Conclusion

The yield of mustard seeds depended on the varietal characteristics, harvesting time, and the use of mineral fertilizers. The highest yields of all varieties were obtained when harvested forty days after the end of flowering, which amounted to 1.18–1.92 t/ha, depending on the genotype of the variety. It was determined that with phosphorus-potassium fertilization without additional feeding, the yield increased to 1.49 t/ha, with a single foliar feeding after emergence against the background of basic fertilization – to 1.77 t/ha, and with two foliar fertilization applications during the sprouting and rosette-stalking phases, it increased to 1.92 t/ha compared to the control. The white mustard varieties Pidpecheretska and Oslava provided a reliably higher seed yield for all harvesting periods. The use of mineral fertilizers did not provide a significant increase in germination energy and seed germination compared to the control, depending on the time of harvest. At the same time, the weight of 1000 seeds naturally and significantly increased depending on the timing of seed harvesting, both in the control and in the case of mineral fertilizers.

References

Angelova, V. and Ivanova, K. (2009). Bioaccumulation and distribution of heavy metals in black mustard (*Brassica nigra* Koch). *Environmental Monitoring Assessment*, 153: 449-459.

Blashchuk, M.I. and Tetereshchenko, N.M. (2014). Influence of sowing dates and doses of mineral fertilisers on the productivity of white mustard. *Scientific and Technical Bulletin of the Institute of Oilseeds of NAAS*, 21: 65-74. (in Ukrainian)

Ehrmantraut, E.R., Prysiazhniuk, O.I. and Shevchenko, I.L. (2007). Statistical analysis of agronomic experimental data in STATISTICA 6.0. Kyiv: PolygraphConsulting, 55. (in Ukrainian)

Fisher, R.A. (2006). *Statistical methods for research workers*. New Delhi: Cosmo Publications, p354.

Gubenko, L.V. and Lyubchych, O.Y. (2020). Influence of fertilizers on the productivity of white mustard. *Cereals*, 4(2): 289–295. DOI: https://doi.org/10.31867/2523-4544/0137. (in Ukrainian)

Hashan, M.N., Mahmud, R., Sizan, M.J.M., Tanim, K.M.Y., Das, B., Khan, R.N.A. and Hoshain S. (2023). Effect of different doses of nitrogen fertilizer (urea) on the yield performance of mustard (*Brassica* sp.). *Research in Agriculture Livestock and Fisheries*, 10(2): 99-107. DOI: https://doi.org/10.3329/ralf.v10i2.68753.

Havryliuk, M.M., Salatenko, V.N., Chekhov, A.V. and Fedorchuk, M.I. (2008). Oilseeds in Ukraine: Study guide. In: V.N. Salatenko (Ed.), p420. (in Ukrainian)

Ivanyshyn, V. and Kasiyanchuk, D. (2024). Analysis of the Impact of Climate Change on the Vegetation of the Perehinsk Territorial Community in Ukraine. *Grassroots Journal of Natural Resources*, 7(2): 199-215. DOI: https://doi.org/10.33002/nr2581.6853.070210.

Jankowski, J.K., Załuskib, D. and Sokolskia, M. (2020). Canola-quality white mustard: Agronomic management and seed yield. *Industrial Crops & Products*, 145: 112138. DOI: https://doi.org/10.1016/j.indcrop.2020.112138.

Jia, P.P., Melnyk, A., Li, L.J., Kong, X.J., Dai, H.F., Zhang, Z.Y. and Butenko, S. (2021). Effects of drought and rehydration on the growth and physiological characteristics

of mustard seedlings. *Journal of Central European Agriculture*, 22(4): 836-847. DOI: https://doi.org/10.5513/JCEA01/22.4.3246.

Kakabouki, I., Karydogianni, S., Roussis, I. and Bilalis, D. (2020). Effect of organic and inorganic fertilization on weed flora and seed yield in black mustard [*Brassica nigra* (L.) Koch] crops. *International Journal of AgrIculture and Natural Resources*, 47(2): 79-89. DOI: https://doi.org/10.7764/ijanr.v47i2.21842020.

Kandel, H. (2022). Tame Mustard Production. North Dakota State University. Fargo, North Dakota. Available online at: https://tinyurl.com/49ubeuk2 [accessed on 12 June 2025].

Khamzina, B., Bulashev, B., Nurmanov, Y., Tultabayeva, T., Nurmukhanbetova, N., Toimbayeva, D., Igimbay, A. and Myrzabayeva, G. (2023). The effects of ammonium phosphate fertilization on yield and yield components of Mustard varieties in chernozem soil. *Eurasian Journal of Soil Science*, 12(2): 169-176. DOI: https://doi.org/10.18393/ejss.1228255.

Kiforuk, I.M., Boichuk O.M., Ivanyuk V.M. and Stelmakh O.M. (2011). Recommendations for growing mustard in the conditions of the Carpathian region. *Manual of the Ukrainian Farme,* 1: 216-222. (in Ukrainian)

Kirilyuk, V.P., Tymoshchuk, T.M. and Kalchuk, M.M. (2019). Yield of white mustard depending on the systems of basic tillage and fertilization. *Scientific Horizons*, 2: 27–33. DOI: https://doi.org/10.332491/2663-2144-2019-75-2-27-33. (in Ukrainian)

Konovalov, D., Polishchuk, V., Konovalova, S. and Brovdi A. (2024). Yield and Quality of Winter Wheat (*Triticum aestivum* L., 1753) Seeds Depending on Pre-Sowing Treatment of Seed with Biological Preparations. *Grassroots Journal of Natural Resources*, 7(3): 22-38. DOI: https://doi.org/10.33002/nr2581.6853.070302.

Melnychuk, T.V, Sendetskyi, V.M., Lys, N.M. and Stelmakh, O.M. (2024). Influence of sowing dates and seeding rates on the formation of white mustard productivity in the conditions of the Carpathian region. *Foothill and Mountain Agriculture and Stockbreeding,* 75(2): 87-97. (in Ukrainian). DOI: https://doi.org/10.32636/01308521.2024-(75)-2-8.

Mykolayko, I.I. (2025). Influence of harvesting time on seed productivity and sowing qualities of mustard seeds. *Newest Agrotechnologies*, 13(1). (in Ukrainian). DOI: https://doi.org/10.47414/na.13.1.2025.32381.

Mykolaiko, I., Polishchuk, V., Balabak, A., Doronin, V. and Brovdi, A. (2024). Formation of Elements of Yield Structure and Quality of Mustard Seeds Depending on Genotype and Mineral Nutrition. *Grassroots Journal of Natural Resources*, 7(3): 110-127. DOI: https://doi.org/10.33002/nr2581.6853.070307.

Mykolaiko, I., Polishchuk, V., Brovdi, A., Karpuk, L., Titarenko, O., Mostypan, O., Zaika, N., Konovalov, D., Yatsenko, A. and Kyzhanjvskiy, V. (2025). Yield and Quality of Mustard Seeds Depending on the Use of Technology Elements. *Grassroots Journal of Natural Resources*, 8(1): 606-619. DOI: https://doi.org/10.33002/nr2581.6853.080125.

Das, N.R. (2009). Human development report 2007/2008 fighting climate change: Human solidarity in a divided world, UNDP, New York. *Soc. Change*, 39: 154-9.

Oksymets, O.L. and Larina, V.I. (2003). Influence of fertilizers and sowing dates on the growth of white mustard. *Institute of Agriculture of the Ukrainian Academy of Agrarian Sciences: A collection of scientific papers*, 87-91. (in Ukrainian)

Palamarchuk, V.D., Doronin, V.A., Kolisnyk, O.M. and Alekseev, O.O. (2022). Fundamentals of seed science (theory, methodology, practice). Vinnytsia: Printing House, Druk, p392. (in Ukrainian)

Pham, V.Q., Pham, M.T., Nguyen, V.T., Nguyen, V.P., Nguyen, D.K.D., Vo, X.H., Thi, T.H.N. and Duong, V.N. (2024). The Effect of LED Lighting Durations on Growth, Yield and Quality of Mustard (*Brassica juncea* L.) under Greenhouse Condition. *Trends in Sciences*, 21(12): 8447. DOI: https://doi.org/10.48048/tis.2024.8447.

Rahman, M., Khatun, A., Liu, L. and Barkla, B.J. (2018). Brassicaceae mustards: Traditional and agronomic uses in Australia and New Zealand. *Molecules*, 23: 231. DOI: https://doi.org/10.3390/molecules23010231.

Sharma, A., Chhabra, V., Mehta, S., Bagal, Y.S., Kumar, R., Al-Ansari, N., El-Hendawy, S., Mattar, M.A. and Salem, A. (2025). Optimizing cultivation practices to enhance growth and yield of Indian mustard. *Scientific Reports*, 15: 11433. DOI: https://doi.org/10.1038/s41598-025-95313-2.

Shevchenko, I.A., Polyakov, O.I., Zhuravel, V.M., Komarova, I.B., Makhno, Y.O., Kuzmenko, O.R., Budilka, H.I. and Usova, N.M. (2019). Harvesting of cereals and early oilseeds in 2019 in Zaporizhzhia region: Recommendations for production. *Zaporizhzhia*, 28. (in Ukrainian)

National Standard of Ukraine (1994). Seeds of agricultural crops. Methods of quality determination. DSTU, 4138-2002. (in Ukrainian)

Zhuikov, O.G. (2006). Method of combine harvesting of Sarepta mustard as a factor of increasing its seed productivity. IX International scientific and practical conference, Science and Education 2006. *Dnipropetrovs'k: Polystar*, 10: 78–80.

Zhuykov, O.G. and Zhuykov, G.E. (2013). The role of mustard and its processed products in the formation of the product segment of the agro-industrial complex of Ukraine. *Business Navigator*, 1: 141–147. (in Ukrainian)

Zhuykov, O.G. (2014). Mustard in the Southern Steppe: agroecological aspects and cultivation technologies. Kherson: Green DS, p416. (in Ukrainian)

Voloshchuk, M.Y. (2024). Formation of yield of white mustard seeds depending on the level of mineral nutrition of plants. *Foothill and Mountain Farming and Animal Husbandry*, 75(1): 18–29. (in Ukrainian) DOI: https://doi.org/10.32636/01308521.2024-(75)-1-2.

Vyshnivsky, P.S., Gubenko, L.V., Remez, G.G. and Lyubchych, O.Y. (2010). Influence of fertilizer system on the formation of productivity of Sarepta mustard (*Brassica juncea* (l.)). *Collection of scientific works of the National Scientific Center Institute of Agriculture of the Ukrainian Academy of Sciences*, (3): 233–237. (in Ukrainian).

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Conceived and designed the research or analysis	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No
Collected the data	No	Yes	No	No	No	No	No	No	No	No
Contributed to data analysis & interpretation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Wrote the article/paper	Yes	Yes	No	No	No	No	No	No	No	Yes
Critical revision of the article/paper	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
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